

REMARKS

Claims 1-60 are pending in this Application. Claims 1, 6, 7, 45 and 46 are amended to clarify the present invention. Claim 3 is cancelled. No new matter is added. Applicants submit that all claims are now in condition for allowance and respectfully request early Notice of Allowance in light of the preceding amendments and following remarks.

Claim 1 is amended to eliminate an antecedent basis issue per the Examiner's request. Specifically, in claim 1 "the" was replaced with "a". The Examiner is thanked for pointing out this issue.

Claim 1 is also amended to further clarify the invention. Specifically, claim 1 is amended to recite "selectively forming a diffusion barrier film on the metal layer" before immersing the wafer holder into the electrolyte solution. Claims 6, 7, 45 and 46, which depend from claim 1, are amended to correspond with the new language of claim 1.

Rejections Under 35 U.S.C § 102(e)

Claim 47 was rejected as being anticipated by US Patent No. 6,447,668 to Wang ("Wang"). Applicants respectfully disagree.

Wang describes a method in which a barrier layer is formed on top of a dielectric layer. The barrier layer is described at col. 8, lines 4-34 and Figure 1A. Specifically, a barrier layer 122 is formed on top of dielectric layer 123. This barrier layer is deposited to prevent the diffusion of copper from copper layer 121 into the underlying dielectric layer 123. Suitable barrier layer materials are those that are "resistant to the diffusion of copper, such as titanium, tantalum, tungsten, titanium-nitride, tantalum-nitride, and the like" (col. 8, lines 22-24). Copper layer 121 is formed on top of barrier layer 122. The copper layer 121 and barrier layer 122 are subsequently electropolished to produce a flat planar wafer surface as shown in Figure 1D.

Claim 47 recites a method in which a diffusion barrier film is formed on a metal layer. The barrier film is then removed to a point where areas of highest elevation of the metal layer are exposed. The exposed regions of the metal are electrochemically removed. The operations of removing diffusion barrier and electrochemically removing metal are repeated iteratively.

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An example of the claimed method is shown in the process flow progression in Figures 3B-3J of the current application. Specifically, a diffusion barrier 311 is formed on a metal layer 309, which is deposited on a dielectric layer 307. Diffusion barrier 311 is then partially removed to expose the metal regions of highest elevation (at the interface of pad 313 and metal layer 309). Next, the exposed metal regions are electropolished to remove a portion of the metal layer 309. The diffusion barrier is preferably a viscous liquid or a solid (preferably a polymer) as described, for example, on page 16, line 19 to page 21, line 8.

The Wang process is fundamentally different in various ways. First, it does not apply a diffusion barrier to a metal film (element (a) of claim 47). Rather, it applies a barrier film to a dielectric. Second, it does not remove the diffusion barrier to expose only areas of highest elevation of the metal layer. Rather, to the extent that the Wang barrier layer is removed, it exposes dielectric – not areas of the metal layer. Still further, Wang fails to suggest repeating (i) removal of the diffusion barrier and (ii) electrochemically removing metal as recited by claim 47. To the extent that Wang's method removes a barrier layer, it does not repeat this process in an iterative fashion.

In short, Wang fails to disclose at least three features of claim 47. This is not surprising given that the barrier layer in Wang has a fundamentally different purpose than the diffusion barrier in the claim 47. The Wang barrier layer is deposited on a dielectric layer to prevent copper diffusion into dielectric portions of the device. The diffusion barrier of the claims is deposited on a metal layer so that higher elevated portions of the metal layer are removed more quickly than other portions of the metal layer. Wang fails to teach or suggest use of a diffusion barrier as recited by claim 47.

Applicants note that the Examiner references column 16, lines 23-28 as disclosing the claim element "removing the diffusion barrier film to expose only the highest elevation of the metal layer." However, this section describes only electropolishing to remove metal – not diffusion barrier. See the beginning of the discussion at column 12, line 46 et seq.

Applicants also note that the Examiner cites the abstract, and particularly the reference to "end point," as meeting the iterative repeating feature recited in claim 47. End point detection is a continuous operation. It has nothing to do with iteratively repeating the operations (b) removing the diffusion barrier film to expose . . . the metal layer, and (c) electrochemically removing metal from the exposed regions of the metal layer

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Therefore, it is respectfully submitted for at least the reasons stated above that claim 47 is patentable over Wang and withdrawal of the rejection of claim 47 is respectfully requested.

Rejections Under 35 U.S.C. § 103(a)

Claims 1-7, 9-17, 21-28, 31-34, 40 and 42-46 were rejected under 35 U.S.C. 103(a) as being unpatentable over U.S. Patent No. 6,176,992 to Talieh ("Talieh") in view of Wang. Applicants respectfully submit that the claims as currently amended are patentable over the cited prior art.

Talieh describes a method of electro-depositing a metal onto certain areas of a wafer surface while simultaneously preventing the accumulation of metal onto other areas using mechanical polishing. In embodiments where a high degree of polish is desired, Talieh teaches that polishing of the substrate using conventional chemical mechanical polishing may be used (col. 3, lines 41-50 and col. 5, lines 22-31).

Claim 1 now recites a method of electroplanarizing a metal layer in which a diffusion barrier formed on the metal layer to prevent diffusion of metal ions during an electrochemical anodization operation. As mentioned previously, this diffusion barrier allows for certain portions of the metal layer to be removed more quickly than other portions of the metal layer.

Talieh fails to teach or suggest such a diffusion barrier. Talieh mentions a "barrier/seed layer" (col. 1, line 13-16) onto which a metal layer may be deposited. However, as in the case with Wang, this barrier layer is a barrier for preventing metal (i.e., copper) from diffusing into dielectric portions of the semiconductor device.

As stated previously, Wang also does not suggest using a diffusion barrier in the manner claimed (e.g., to selectively remove exposed regions through the diffusion barrier of metal via electropolishing). It is, therefore, respectfully submitted for at least the reasons stated above that claim 1 is patentable over Talieh in view of Wang and withdrawal of the art rejections for claim 1 is respectfully requested.

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Claims 2, 4-7, 9-17, 21-28, 31-34, 40 and 42-46 each depend directly from claim 1 and are, therefore, respectfully submitted to be patentable over the art of record for at least the reasons set forth above with respect to the claim 1.

Claims 8, and 18-20 were rejected under 35 U.S.C 103(a) as being unpatentable over Talieh in view of Wang and further in view of one of U.S. Patent No. 6,171,467 to Weihs et al. or U.S. Patent No. 5,203,955 to Viehback et al. However, these references fail to overcome the deficiencies of the primary references. Withdrawal of the rejections of these claims is respectfully requested.

Claims 48-58, which directly depend upon independent claim 47, are rejected as being unpatentable over Wang in view of Talieh. It is submitted that these claims are patentable over Wang for at least the reasons stated above for patentability for claim 47 and that Talieh fails to overcome the deficiencies of Wang. Withdrawal of the rejections of these claims is respectfully requested.

Each of claims 29-30, 35-39 and 41 is objected to as being dependent upon the rejected claim1. Withdrawal of the objections of these claims is respectfully requested in light of the amendment to claim 1. Each of claims 59-60 is objected to as being dependent upon the rejected claim 47. Withdrawal of the objections of these claims is respectfully requested for at least the reasons set forth above with respect to claim 47.

Withdrawal of all rejections under 35 U.S.C. 103(a) is therefore respectfully requested.

For at least the reasons stated above, withdrawal of all rejections under 35 U.S.C 102 and 35 U.S.C. 103 is respectfully requested.

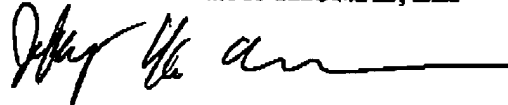
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Conclusion:

In light of the foregoing amendments and remarks, Applicants respectfully submit that all pending claims are now in condition for allowance. Thus, Applicants respectfully request a Notice of Allowance from the Examiner. Should any unresolved issues remain, the Examiner is encouraged to contact the undersigned at the telephone number provided below. If the Commissioner determines that any additional fees are due, such fee may be charged to deposit account No. 50-0388 (Order No. NOVLP001X1).

Respectfully submitted,

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